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ABSTRACT

Uses the Questionnaire on Teacher Interaction (QTI) to identify and describe better primary science teachers. With a sample of 753 science students, the reliability of the QTI scales ranged from 0.61 to 0.85. The better teachers were identified as those whose students' perceptions were more than one standard deviation above the mean on the scales of Leadership, Helping/Friendly, and Understanding and more than one standard deviation below the mean on the Dissatisfied and Admonishing scales. The construct validity of the QTI was confirmed through interviews with students and these views are reported in the paper. (Author)

The characteristics of better primary science teachers

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IDENTIFYING BETTER PRIMARY SCIENCE TEACHERS USING STUDENT-TEACHER INTERACTIONS

ABSTRACT. The purpose of the study described in this paper was to use the Questionnaire on Teacher Interaction (QTI) to identify and describe better primary science teachers. With a sample of 753 science students, the reliability of the QTI scales ranged from 0.61 to 0.85. The better teachers were identified as those whose students' perceptions were more than one standard deviation above the mean on the scales of Leadership, Helping/Friendly, and Understanding and more than one standard deviation below the mean on the Dissatisfied and Admonishing scales. The construct validity of the QTI to identify these better priamry science teachers was confirmed through interviews with students and these views are reported in the paper.

1. INTRODUCTION

The recently released DETYA report *The Status and Quality of Teaching and Learning of Science in Australian Schools* (Goodrum, Hackling, & Rennie, 2001) provides a contemporary, informative and disappointing picture of the current state of science education in Australia:

> The actual picture of science teaching and learning is one of great variability but, on average the picture is disappointing. In some primary schools, often science is not taught at all. When it is taught on a regular basis, it is generally student-centred and activity-based, resulting in a high level of student satisfaction. When students move to high school, many experience disappointment, because the science they are taught is neither relevant nor engaging and does not connect with their interests and experiences. Traditional chalk-and-talk teaching, copying notes, and 'cookbook' practical lessons offer little challenge or excitement to students. Disenchantment with science is reflected in the declining numbers of students who take science subjects in the post-compulsory years of schooling. (p. 3)

In another recent study, *Foundations for Australia's Future - Science and Technology in Primary Schools* (Stocker, 1997, p. 1), stated that 'much has been achieved in primary science and technology education over the past ten years but much more needs to be done'. Also, *The*

teaching of science & technology in Australian primary schools: A cause for concern that was prepared by the Australian Academy of Technological Sciences and Engineering (2002 p. 13) stated that

> it is clear by their own assessment, the great majority of primary teac hers are ill prepared to teach the content of the new science and technology curricula. This is not a criticism of these professionals who have seen the system's expectations of them evolve into demands for which they are ill prepared. They lack both the competence and the confidence.

These are but three of a range of studies which over the last few decades have described the disappointing state of teaching of science at all school levels across many countries (e.g., Brown, 1974; Harlen, 1999; Tobin & Fraser, 1988; Yager, Hidayat, & Penick, 1988). It is therefore important to investigate what is occurring in science classrooms to provide a focus for improving the situation.

Some researchers in science education have tried to achieve this by identifying and describing the behaviour of very good or exemplary science teachers believing that if we can do this the descriptions of what these teachers do may lead to an overall improvement in student outcomes. However, exemplary teachers have been difficult to identify and researchers have found it difficult to describe what is exemplary teaching. Just profiling effective teaching by scoring whether effective practices are present is of little value in that ineffective teachers can also display some of these practices (Cruikshank, 1986). A teacher might be able to display a variety of competencies, but lack the skills necessary to put these components together, and different teachers may put them together in quite different ways.

A wide variation in the beliefs and practices of teachers has been observed from classroom observations and interviews. Van den Akker (1998), in describing schools that had productive primary science programs, revealed that these schools had:

> a high level of student involvement and enthusiasm; increased student initiative in the learning process; a lot of group work and interaction; teaching involving stimulation and facilitation; increased variety of resources (materials and objects) and experiences; extensive integration of science topics with project-oriented activities over a long period; and a lot of emphasis on process skills for exploration, learning to learn, and attitudinal goals such as curiosity, precision and perseverance. (p. 436)

Other attempts to delineate teacher standards lie in the description of a set of skills and techniques that good teachers embrace in their practice. These standards define, for instance, the skills and knowledge required for teachers to achieve registration, or to be promoted to master teachers. In science teaching, these standards could describe the knowledge of science content, planning and management strategies, assessment processes, or utilisation of science resources.

A Western Australian study (Tobin & Fraser, 1988) focused on case studies of classroom practices employed by exemplary teachers. The project was explicitly framed within constructivist principles, which are claimed to lead to greater value being placed on higher-order cognitive learning (Tobin & Fraser, 1990). The project reported considerable diversity in the methods these teachers used, but nevertheless produced four assertions concerning exemplary science teachers. The assertions were that these teachers used management strategies that facilitated sustained student engagement, used strategies designed to increase student understanding of science; utilised strategies that encouraged students to participate in learning activities and maintained good interactions with their students through the provision of a favourable classroom learning environment (Tobin & Fraser, 1988, 1990).

Allied to this project, a study by Treagust (1991) of two exemplary biology teachers, created a similar list of assertions. Treagust described how the two teachers had rather different styles of structuring the lessons, and how their interactions with and expectations of students, related to their personalities and teaching philosophies. Treagust made five assertions to describe what the teachers had in common that characterised the exemplary nature of their practice. The assertions were that these teachers exhibited high levels of classroom management and organization styles, encouraged learning from students of different ability levels, encouraged students to engage in academic work, set high academic expectations, and encouraged student input by referring to it.

In each of these studies, one of the behaviours of the better teachers was their favourable interactions with their students. It was thus decided to build on this past research and focus this study on the identification and description of better science teachers through their teacher-student interactions.

2. TEACHER-STUDENT INTERACTIONS

Recent reviews (e.g. Fraser, 1998; Fraser & Walberg, 1991) show that science education researchers have led the world in the field of classroom environment over the last two decades, and that this field has contributed much to understanding and improving science education. A key to improving student achievement and attitudes is to create learning environments that emphasise those characteristics that have been found to be linked empirically with favourable student outcomes. One particular development in classroom environment research occurred in The Netherlands where the focus was on the interactions that occurred between teachers and students. Wubbels, Creton and Holvast (1988) investigated teacher behaviour in classrooms from a systems perspective, adapting a theory on communication processes developed by Watzlawick, Beavin and Jackson (1967). Within the systems perspective on communication, it is assumed that the behaviours of participants influence each other mutually. The behaviour of the teacher is influenced by the behaviour of the students and in turn influences student behaviour. Circular communication processes develop which not only consist of behaviour, but determine behaviour as well.

With the systems perspective in mind, Wubbels, Creton and Hooymayers (1985) developed a model to map interpersonal teacher behaviour extrapolated from the work of Leary (1957). The model maps interpersonal behaviour with the aid of an influence dimension (Dominance, D - Submission, S) and a proximity dimension (Cooperation, C - Opposition, O). These dimensions are represented in a coordinate system divided into eight equal sectors. Every instance of interactional teacher behaviour can be placed within this system of axes (Figure 1).

This model has been used in The Netherlands in the development of an instrument, the *Questionnaire on Teacher Interaction* (QTI), to gather students' perceptions of their interactions with their teacher (Wubbels & Levy, 1993). The QTI contains eight scales based on the eight parts of the model. Table I presents a description and a sample item of each scale of the QTI.

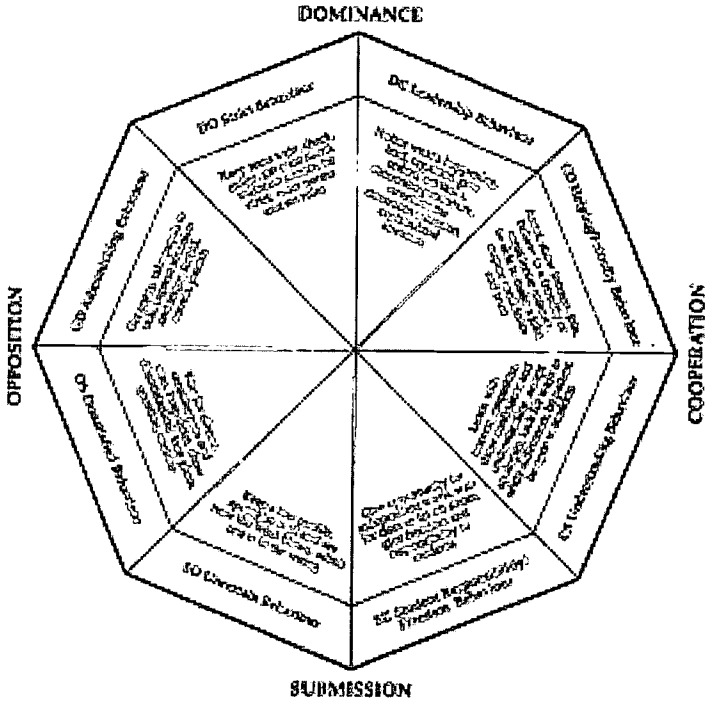

Figure 1. The model for interpersonal teacher behaviour (Fisher, Fraser & Wubbels, 1993).

TABLE I. Description of Scales and Sample Items for each Scale of the QTI

Scale Name	Description of Scale (The extent to which the teacher...)	Sample Item
Leadership	...leads, organises, gives orders, determines procedure and structures the classroom situation.	This teacher knows what is going to happen next in this class.
Helping/Friendly	...shows interest, behaves in a friendly or considerate manner and inspires confidence and trust.	This teacher helps us with our work.
Understanding	...listens with interest, empathises, shows confidence and understanding and is open with students.	This teacher trusts us.
Student Responsibility/ Freedom	...gives opportunity for independent work, gives freedom and responsibility to students.	This teacher allows us to take responsibility for what we do.
Uncertain	...behaves in an uncertain manner and keeps a low profile.	This teacher allows us to tell him/her what to do.
Dissatisfied	...expresses dissatisfaction, looks unhappy, criticises and waits for silence.	This teacher thinks that we cheat.
Admonishing	...gets angry, expresses irritation and anger, forbids and punishes.	This teacher gets angry quickly.
Strict	...checks, maintains silence and strictly enforces the rules.	This teacher is strict.

The QTI is an unusual learning environment instrument in that it is based on a two-dimensional circumplex model for interpersonal behaviour. The circumplex nature of the model means that the interscale correlations are highest between adjacent scales, and lowest and negatively correlated with scales that are opposite. Thus the scales opposite each other in the model describe opposite types of teacher behaviour.

The QTI has been shown to be a valid and reliable instrument when used in The Netherlands (Wubbels & Levy, 1993). When the 64-item USA version of the QTI was used with 1,606 students and 66 teachers in the USA, the cross-cultural validity and usefulness of the QTI were confirmed. Using the Cronbach alpha coefficient, Wubbels and Levy (1993) reported acceptable internal consistency reliabilities for the QTI scales ranging from 0.76 to 0.84 for student responses and from 0.74 to 0.84 for teacher responses.

An initial use of the QTI in The Netherlands involved an investigation of relationships between perceptions on the QTI scales and student learning outcomes (Wubbels, Brekelmans &

Hooymayers, 1991). Regarding students' cognitive and affective outcomes, teachers leadership, understanding, and helping/friendly behaviours were associated with the better student achievement. Conversely, admonishing, uncertain and dissatisfied behaviours were related negatively to achievement. Wubbels and Brekelmans (1998) confirmed that student outcomes are indeed related to student perceptions of teacher behaviours. In another study, Wubbels and Levy (1993) claimed that student perceptions of interpersonal teacher behaviour appeared to account for 70% of the variability in student achievement and 55% for attitude outcomes.

The Australian version of the QTI containing 48 items was used in studies involving upper secondary science classes in Western Australia and Tasmania (Fisher, Fraser & Wubbels, 1993; Fisher, Fraser, Wubbels & Brekelmans, 1993; Fisher, Henderson, & Fraser, 1995). These studies confirmed the reliability and validity of the QTI and noted that generally, the dimensions of the QTI were found to be significantly associated with student attitude scores. In particular, students' attitude scores were higher in classrooms in which students perceived greater leadership, helpful/friendly, and understanding behaviours in their teachers.

In a study of middle secondary science classes, students' attitude scores were higher in classrooms in which students perceived greater leadership, helping/friendly, and understanding behaviours in their teachers. Females perceived their teachers in a more positive way than did males and students from an Asian background tended to perceive their teachers more positively than those from the other cultural groups identified in the study (Fisher & Rickards, 1997).

In another study in which the QTI was used in Australia, the perceptions of 490 mathematics students were used. It was found that students developed more positive attitudes towards their mathematics in classes where the teacher showed leadership, helping-friendly behaviour and minimal admonishment of students. Student cognitive gains were least in classes where students perceived that the teacher was dissatisfied, gave them too much freedom and responsibility, and where they were involved in investigations (Rawnsley & Fisher, 1997).

Now the Australian version of the QTI has been used in many studies involving science classes across Australia (Fisher, Fraser & Wubbels, 1993; Fisher, Fraser, Wubbels & Brekelmans, 1993; Fisher, Henderson & Fraser, 1995; Fisher, Rickards & Fraser, 1996; Fisher & Waldrip, 1999). These studies all confirm the validity and usefulness of the QTI.

Generally, higher cognitive outcome scores and attitudinal outcomes are positively associated with leadership, helping, friendly and understanding teacher behaviours while strict or controlling behaviours are associated with higher cognitive outcomes and to a lesser extent with attitudes (She & Fisher, 2000). Conversely, admonishing, dissatisfied and uncertain teacher behaviours are negatively associated with students' cognitive and attitudinal outcomes. Therefore, it was decided to investigate the usefulness of the QTI to identify better science teachers, those who would receive higher scores on the Leadership, Helping/Friendly and Understanding scales and lower scores on the Admonishing, and Dissatisfied scales. The study reported here was concerned with student-teacher interactions in primary classrooms. The study is distinctive in that it uses the perceptions of students' interactions with their teachers in the identification of better teachers.

3. METHOD

The aim was to use the QTI to identify and describe better primary science teachers. These better teachers were identified through their scores on particular scales of the QTI. The suitability of the QTI in this identification process was checked by interviewing the school principals of these teachers. Finally, the construct validity of the QTI to identify better teachers was confirmed through interviews with students.

The study involved a sample of 753 primary science students and their teachers in 34 Australian primary school classrooms. These teachers consisted of volunteered government primary science teachers within regional Victoria and metropolitan Perth, Western Australia. Each student in the sample responded to the QTI and the results for each class were calculated as scores on each scale of the QTI. The better teachers were defined as those whose students' perceptions were more than one standard deviation above the mean on the scales of Leadership, Helping/Friendly, and Understanding and more than one standard deviation below the mean on the Dissatisfied and Admonishing scales. The authors were interested in establishing a method that was relatively simple for practising teachers and researchers to utilise and that was an alternative to some previous studies that employed a comparison of students' ideal and actual interpersonal styles (Wubbels, Brekelmans & Hooymayers. 1991).

A number of students from classes that had indicated very positive student-teacher interactions were interviewed to examine why these students had such positive perceptions. The interviews thus examined the veracity of student perceptions. Only one class within a school was involved in the interview process. From each class, four students were interviewed separately. The students were chosen by the teacher concerned so that a range of ability and interest in science was achieved. The resulting students fell into four groups; high achieving/high interest; high achieving/low interest; struggles academically/high interest; and struggles academically/low interest.

During the interviews, we were interested in further examining the students' perceptions of the scales that the individual items were measuring. The students were asked questions that explored the following. What do they think that item meant? Did the concept of each scale appear to be important to them? How did they interpret each scale? What disconfirming evidence existed in students' perceptions for each scale? Did the scales reflect characteristics of their best teachers?

4. RESULTS

4.1. *Instrument Reliability*

The reliability and validity of the QTI instrument was checked. The internal consistency/reliability (Cronbach alpha reliability coefficient) and scale item mean of each of the QTI scales are shown in Table II. The table shows that when using the individual student as the unit of analysis, the alpha coefficients ranged from 0.61 to 0.85 confirming that each QTI scale has acceptable reliability, especially for scales containing a relatively small number of items. The sample of classes was too small to use the class mean as the unit of analysis. The scale item means (range 0 to 1) showed that the scales of Leadership, Helping/Friendly, Understanding, Student Responsibility/Freedom and Strict behaviour were the most strongly perceived scales while their were lower perceptions of the less desirable scales of Dissatisfied and Admonishing. Another desirable characteristic of a questionnaire like the QTI is that it is capable of differentiating between perceptions of students in different classes. This was of added importance here because we were interested in whether the QTI could distinguish between the classrooms of exemplary and other teachers. This characteristic was explored using a one-way

ANOVA with class membership as the main effect using the individual as the unit of analysis. The results in Table 2 indicated that each scale differentiated significantly ($p<0.01$) between classes. The eta^2 statistic represents the amount of variance in student-teacher interaction scores accounted for by class membership and in this study it ranged from 0.19 to 0.39.

TABLE II. Cronbach Alpha Reliability, Item Mean, Standard Deviation and Ability to Distinguish Between Classes for Each Scale of the QTI

Scale	No of items	Unit of analysis	Alpha reliability	Scale item mean	Standard deviation	ANOVA results eta^2
Leadership	6	Individual	.68	.58	.16	.22*
Helping/ Friendly	6	Individual	85	.65	.20	.29*
Understanding	6	Individual	.82	.61	.19	.27*
Student Resp/ Freedom	6	Individual	.71	.54	.17	.24*
Uncertain	6	Individual	.61	.26	.16	.19*
Dissatisfied	6	Individual	.76	.29	.18	.27*
Admonishing	6	Individual	.83	.33	.23	.39*
Strict	6	Individual	.70	.46	.18	.21*

n= 753 students and 34 teachers *$p<0.01$

4.2. *Identification of Exemplary Teachers*

Of the 34 teachers involved in the study, there were six teachers whose students reported significantly different interactions. We referred to these teachers as the better teachers. It is clear from the results presented in Table III, and depicted in Figure 2, that these teachers did indeed have higher scores (more than one standard deviation above the mean) on the scales of Leadership, Helping/Friendly, and Understanding and lower scores (about one standard deviation below the mean) on the Dissatisfied and Admonishing scales.

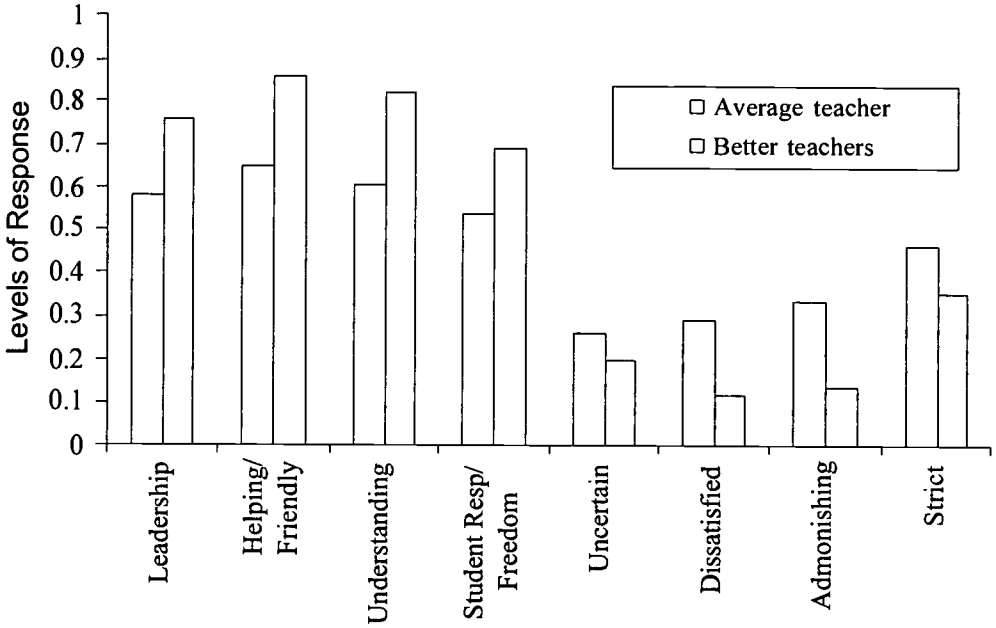

Figure 2. *Mean Scores for Average and Exemplary Teachers for each Scale of the QTI.*

Table III. Mean Scores for Average and Exemplary Teachers and Difference in Standard Deviations for Each Scale of the QTI

Scale	Average teacher	Better teachers	Difference in s.d.'s
Leadership	.58	.80	+1.47
Helping/ Friendly	.65	.86	+1.10
Understanding	.61	.82	+1.17
Student Resp/ Freedom	.54	.69	+0.94
Uncertain	.26	.20	-0.39
Dissatisfied	.29	.12	-1.42
Admonishing	.33	.14	-1.05
Strict	.46	.35	-0.61

In order to check the QTI scores, we discussed the quality of each of these six teachers with their principals. The principals had been told that these teachers were being chosen from classes that had reported very favourable student-teacher interactions. The principals indicated that they were not surprised that these teachers were chosen and that they could understand why these classes were chosen as these teachers were considered to be highly exemplary. As some principals stated:

She has really turned primary science on it head. No one liked taking it before.
He has the students' interests at heart and makes learning relevant to them. Hre engages them with what he is teaching them.
He involves the students in the learning process. He both leads and facilitates learning.
She shows a real love for science and the students. She wants them to learn.

4.3 *Student Interviews*

As described in the methodology, four students from each of the six classes that had indicated very positive student-teacher interactions were interviewed to examine why these students had such positive perceptions. The interviews therefore examined the veracity of the students' perceptions.

As discussed earlier, the QTI utilises opposing dimensions and it became apparent in the interviews that the students' comments reflected these opposing dimensions. Therefore, it was decided to report each of these two dimensions together.

4.3.1. *Leadership versus Uncertain*

These scales were designed to measure the extent to which the teachers made it clear that they knew what they were doing in the classroom. When we interviewed the students about the degree of leadership their teacher displayed, students indicated that they learnt a lot from the teacher and all course-related material was explained clearly in the class. These students when asked about how uncertain their teacher was, always emphasised the positive leadership qualities of their teacher.

I know I learnt because I can tell my Mom and Dad
She is aware as to what is happening in the classroom.
She knows what we are doing.
She walks around and looks at what you do and then helps you.
She will complement us when we do a good job.

I have learned a lot from him. Because I didn't learn when I came into Grade 3 but then he taught me some strategies.

4.3.2 *Helping/ Friendly versus Dissatisfied*

The intent of these scales was to measure the extent that the teachers helped them and viewed them as being capable students. These students saw that their teacher was very helpful and friendly.

She tells you things that you can improve upon.
She will help me if I don't know what I am doing
She shows us good ways as to how to do something
She helps me all the time. When we did invertebrates, she would help as I didn't know too much. If you are having trouble, she will help you out.
If you are having trouble, she will help you out.
She will complement us when we do a good job.
He gets to know all the students.

4.3.3. *Understanding versus Admonishing*

Students in these classes saw that their teachers knew the extent to which their students understood, listened to them and did not become angry quickly.

He can tell by my face if I don't understand. He shows me how to do it.
I have learnt heaps since coming to this school.
If you haven't been listening, sometimes she asks why you haven't been listening. I am pretty sure that she will help you then.
It takes a bit to get her angry
She can tell if we are confused by looking at our face. Then she would ask if we are confused. Then she would do it in case.
She cares for us. She won't let us out of her sight. She only lets us go outside unless we have her or another teacher or two other students with us.
She doesn't raise her voice very much.
She knows if I am listening as she looks at me. She explains really well.

She only gets cranky when she knows that something is wrong or someone has done something naughty or plays up.

He listens. He doesn't overtake you. He waits until the end to put in his own opinion.

Schools that emphasized concepts of 'caring' had their students emphasizing the view that students and staff did care for each other. Finally, these students emphasized that their contribution in class were valued by the teacher, they were active in the learning process and challenged by their teachers.

She doesn't criticise your work much but if you do it neat she will try and get you to make it neater.

She listens to what I have to say and then uses my answer to make us think more

She faces me and really likes me.

4.3.4. *Student Responsibility and Freedom versus Strict*

Students in the better classrooms felt that they were given some choice in how they approached their learning. Their teachers gave them responsibility and allowed them to make suggestions.

The students felt that they were given responsibility.

Because when she had our project, she trusts us to do errands for her.

If given a task, she can trust you.

We get choice. We can't exactly what we want to do but we can say what we think of this project. We can kind of challenge her as she is our teacher.

That he signs me up for things that he thinks I would be good at, that I can handle, solve the problem.

If it is not a reasonable answer, then I will challenge him. If I tell him that he is wrong, he jokes about it. So he fixes it up.

He trusts me. You have to earn his trust. Do good work for him.

The concept of strictness was somewhat relative. When students were pressed to indicate whether they preferred more or less strictness, students expressed the status quo or for their teachers to be slightly more strict. They felt that teachers becoming less strict would provide a negative effect on learning. They saw that the present level of strictness was fair and essential for learning.

Most of the time she is not [too strict]
She is pretty strict in that she won't let us out of her sight.
She is when boys are being silly.
She is really good. Just right.
He is tolerant. He is on and off.

I: If you had to choose between being more or less strict, what would you choose?
Less strict because then you can talk to your friends and not work
More strict because then we wouldn't be able to get into trouble or mischief.
More strict. We learn more.

When they were asked to suggest how their teachers could improve, typical of good teaching, the students struggled to provide an answer for this question. These students do enjoy their science lessons. All these students made a point that they felt that they were involved in the learning science process. They saw learning in these classrooms as collaborative and that they as students, were actively involved in the learning process. Many of these students were able to explain how what they learnt in the classroom affects or helps what they do at home or their parents in their work. The students tended to refer to the process of teaching rather than concentrate on the content of what was or should be taught.

Even when they were pushed to state what faults their teacher had, they tended to struggle to identify any.

Don't be as strict as you can be. Let us do what we really want
I don't really know
She is perfect.
We could do more science. It's good
Not much really.
I don't know what could make him better. He makes things fun.
Stop smoking. It annoys me. It is the only thing that I don't like about him.
Be a bit more more strict.

If they were asked if they would like to be in another class, they replied

Not really. Because I like that class.
Disappointed because I don't know what that class is like.

Not good.

Lonely. In wouldn't talk, or answer questions. I would be just couped up.

5. DISCUSSION

This article has provided further evidence on the validation of the QTI which assesses eight scales of teacher interactions with primary school students. The reliability for each scale was obtained and the Cronbach alpha coefficients ranged between the acceptable values of 0.61 and 0.85. Additionally, the QTI's ability to distinguish between classes was confirmed which was important factor for this study.

It was found that better primary science teachers could be identified through the perceptions of their students on the scales of the QTI. The better teachers were those whose students' perceptions were more than one standard deviation above the mean on the scales of Leadership, Helping/Friendly, and Understanding and about one standard deviation below the mean on the Dissatisfied and Admonishing scales.

The construct validity of the QTI to identify better teachers was confirmed through interviews with students and these views are reported in the paper. It was interesting to note that even though students did not use the term constructivism, it was clear that the students of the exemplary teachers were describing constructivist principles driving their learning. When asked if they would like to have a different teacher, they typically responded like:

She is the best science that we ever had. She helps you out.
Probably the best teacher I ever had. He is fun.

Students reported that they were able to apply what they had learnt in class to various aspects of their home life. One student went on to explain how they could use what they had learnt about in force and motion to the workings on their farm. Other students talked about how they would share what they had learnt with their parents.

It is apparent from these interviews that these better teachers tried to interest students in the learning process, understood the needs of their students in the learning process, were friendly,

gave students responsibility and had a level of strict behaviour with which students were comfortable and felt was conducive to their learning.

Overall, this study has shown that identifying exemplary teachers through the use of students' perceptions of their interpersonal behaviour is worthwhile and that further study employing the QTI would be valuable. In particular, we now need to obtain more detailed descriptions of the classrooms where these teachers are operating. The authors believe that all teachers could use the QTI as a tool to provide feedback for reflection. The results from using the QTI also could be used as evidence of change when teachers self-report their assessment of their own teaching.

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